# Climate Impacts on Annual-Average Airborne Particle Source Contributions in California

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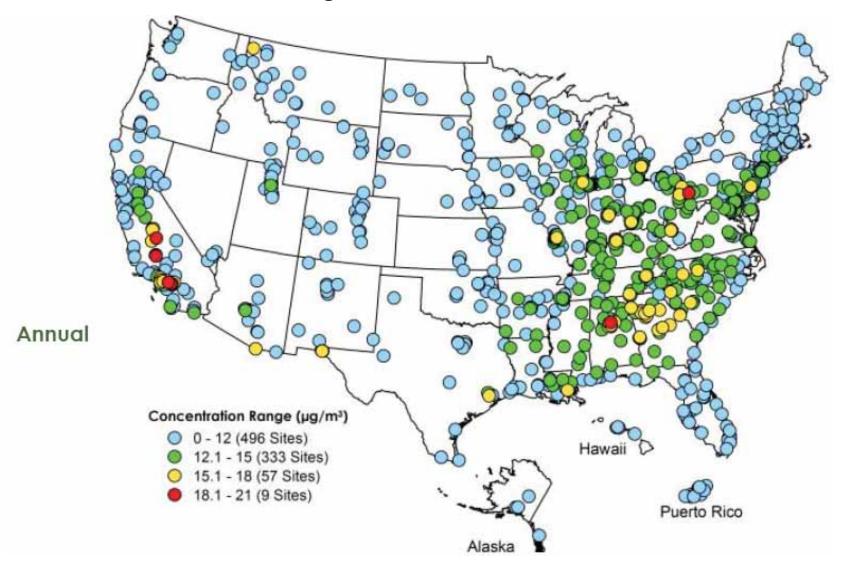
Zhan Zhao, Jianlin Hu, and Shu-Hua Chen Atmospheric Science



University of California at Davis

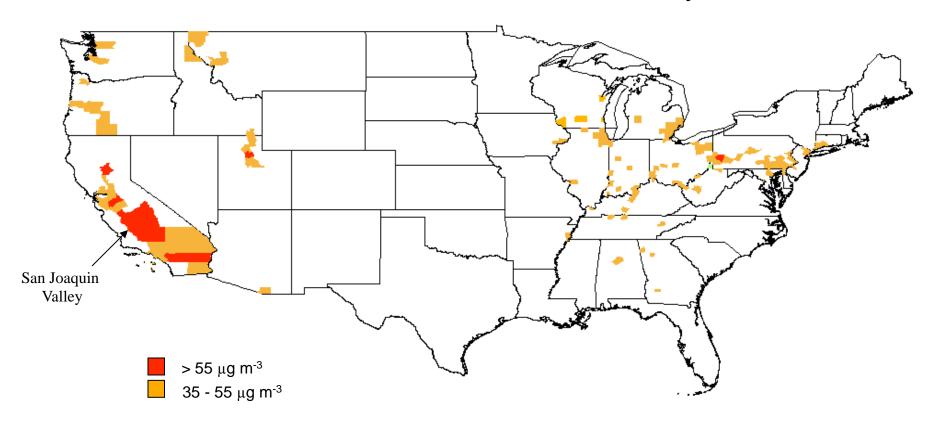


#### Annual average PM2.5 concentration 2006



Source: US EPA (http://www.epa.gov/air/airtrends/2007/report/particlepollution.pdf).

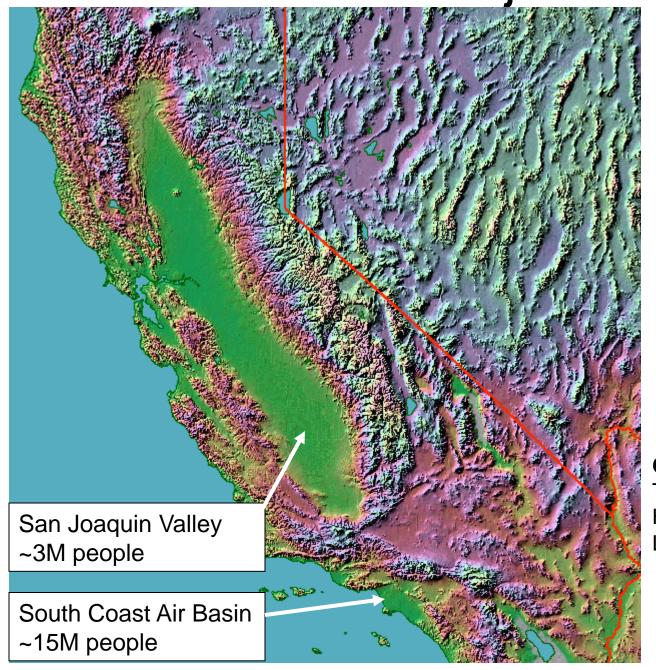
# 98th percentile PM2.5 concentrations (24-hr average) measured in United States counties for the years 2005-07



Values below the NAAQS (35 μg m<sup>-3</sup>) are not shown. Data accessed from http://www.epa.gov/airtrends/values.html August 1, 2009.

Source: M. Hixson, A. Mahmud, J.Hu, S. Bai, D. Niemeier, S.L. Handy, S. Gao, J. R. Lund, D. Coe Sullivan, and M.J. Kleeman1. "Influence of Regional Development Policies and Clean Technology Adoption on Future Air Pollution Exposure", Atmospheric Environment, submitted for publication, 2009.

## California's Major Air Basins



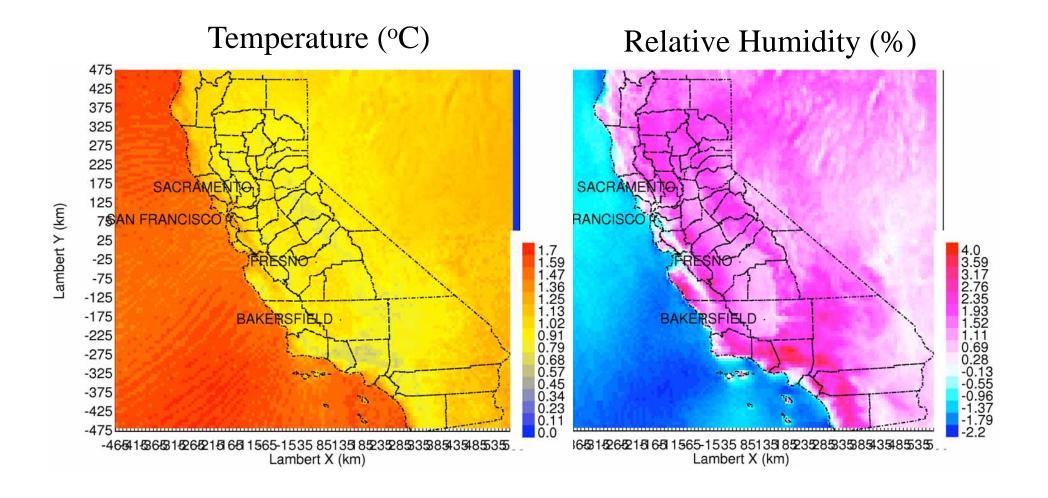
#### **California Facts:**

Top 10 world economy
Highest point in continental US
Lowest point in continental US

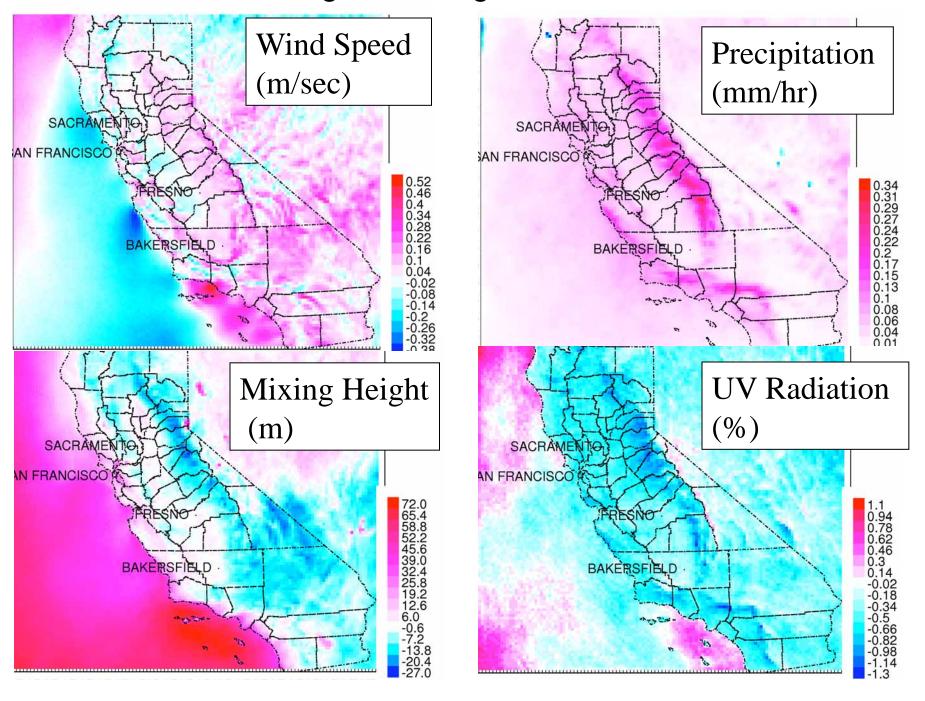
# Approach

- Dynamic Downscaling of PCM results using WRF (CARB project#04-349)
  - 2000-06; 2047-53 (126 days simulated each year)
  - SJV summer (O3) and winter (PM)
  - SoCAB summer (O3) and fall (PM)
- Future Emissions Inventory Projection (EPA project#RD83184201)
  - SJV 2030 and 2050; SoCAB 2050
- Air Quality Simulations for 28 years
  - Current emissions with present + future meteorology
  - Future emissions with present + future meteorology
  - UCD source-oriented air quality model
    - ISORROPIA II Fountoukis and Nenes (2007)
    - Dynamic gas to particle conversion Jacobson (2005)

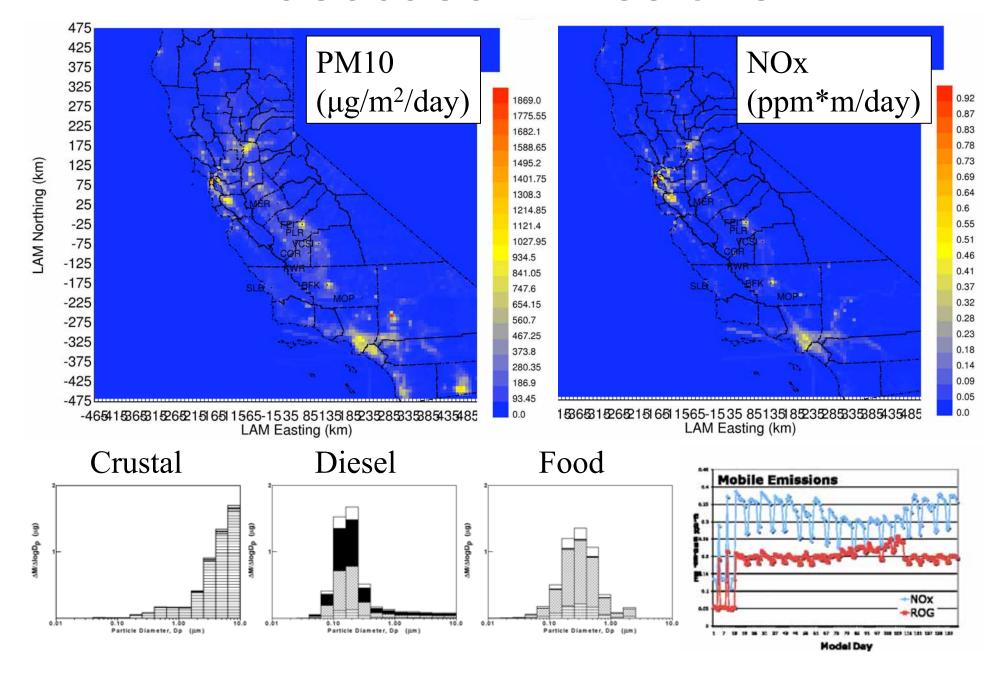
# Temperature and Humidity Changes 2047-53 vs. 2000-06



#### Other Meteorological Changes 2047-53 vs. 2000-06



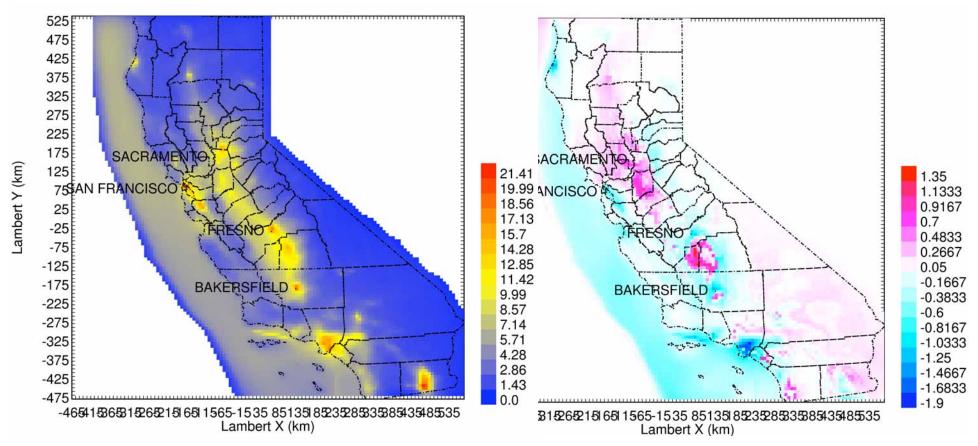
### **Basecase Emissions**



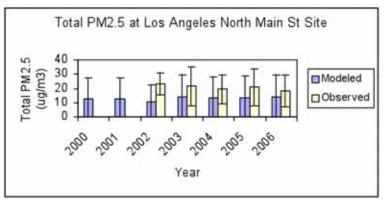
# PM2.5 Mass Change 2047-53 vs. 2000-06

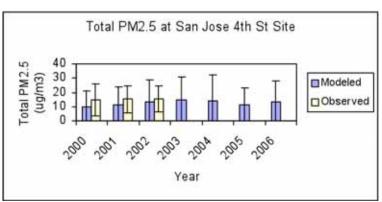
Basecase PM2.5 ( $\mu$ g/m<sup>3</sup>)

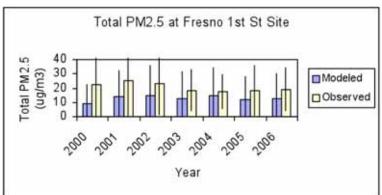
 $\Delta$  PM2.5 ( $\mu$ g/m<sup>3</sup>)

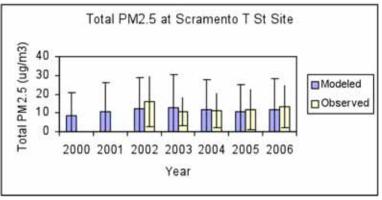


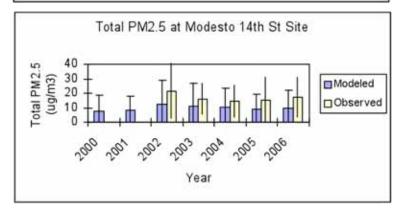
#### Comparison to Measured Values 2000-06

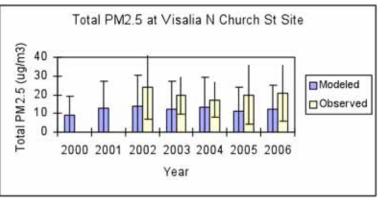








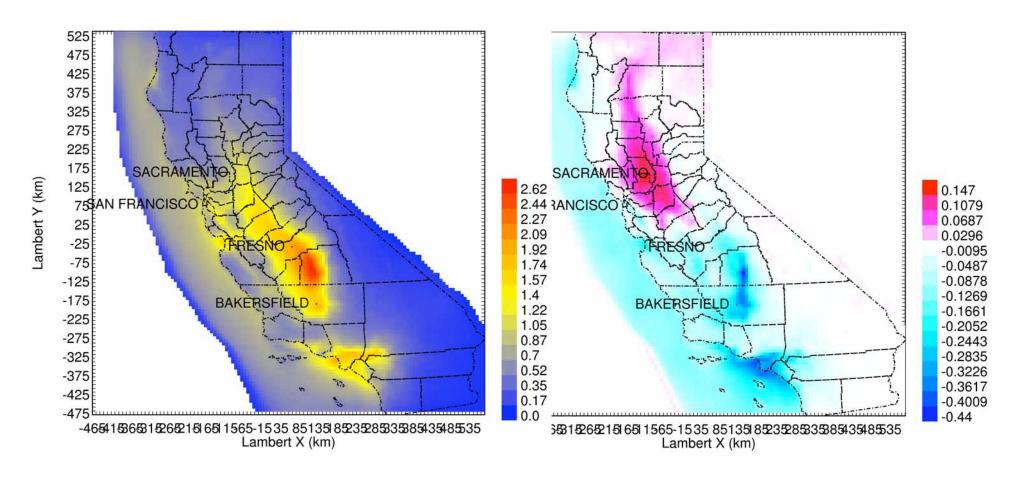




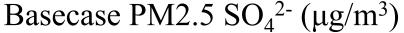
# PM2.5 NO<sub>3</sub> Change 2047-53 vs. 2000-06

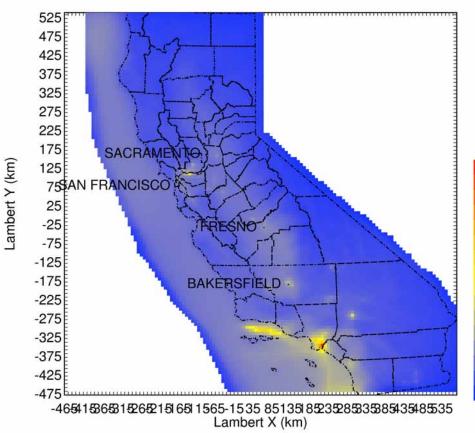
Basecase PM2.5 Nitrate (μg/m<sup>3</sup>)

 $\Delta$  PM2.5 Nitrate (µg/m<sup>3</sup>)

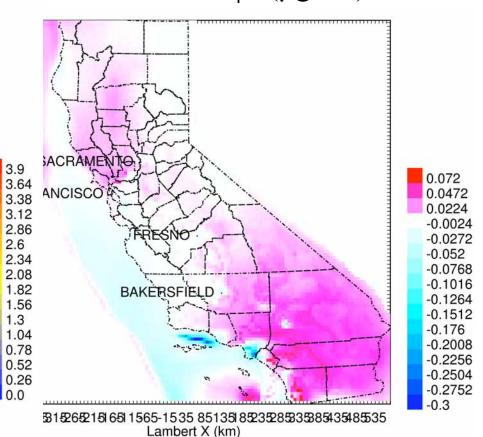


# PM2.5 SO<sub>4</sub><sup>2-</sup> Change 2047-53 vs. 2000-06

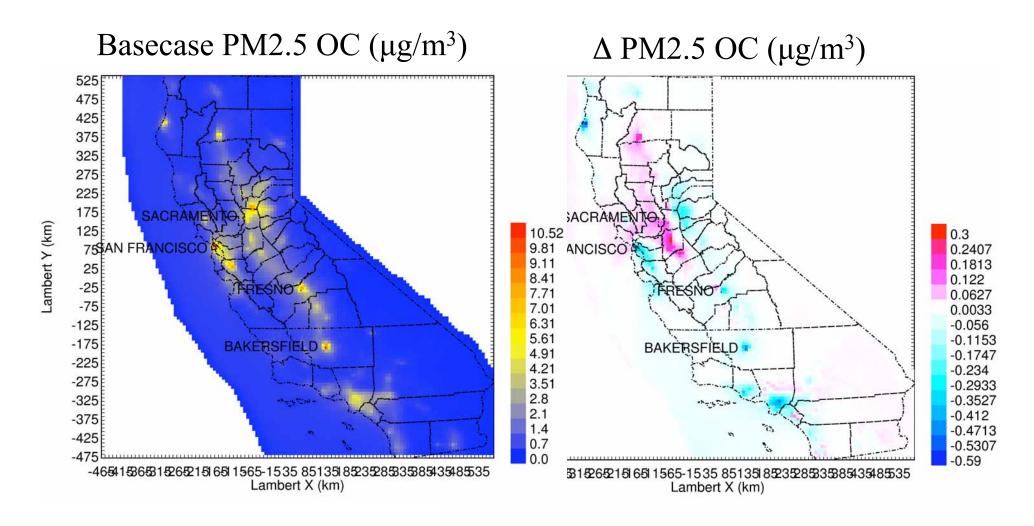




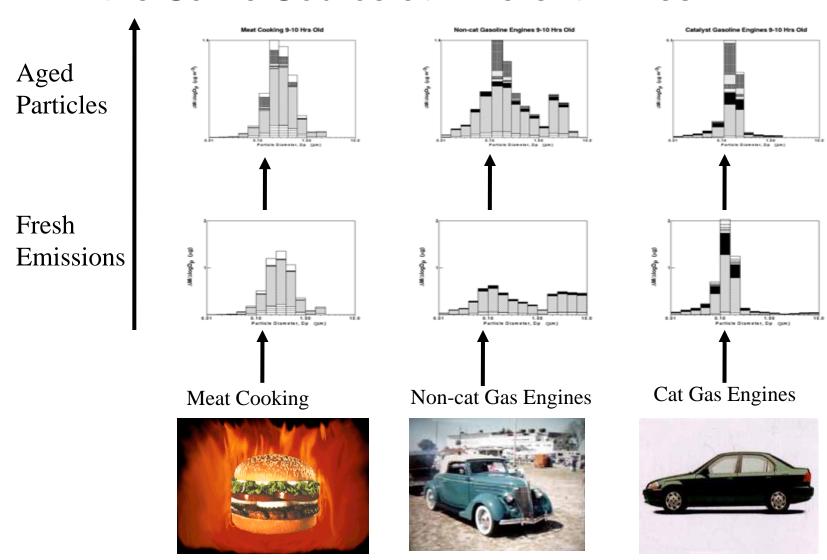
#### $\Delta \text{ PM}2.5 \text{ SO}_4^{2-} (\mu \text{g/m}^3)$



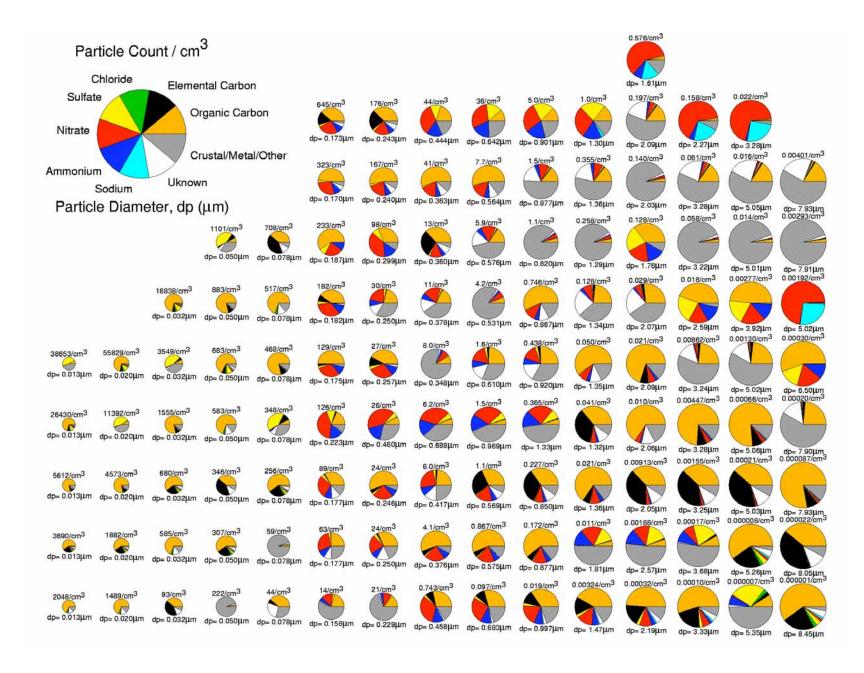
# PM2.5 OC Change 2047-53 vs. 2000-06



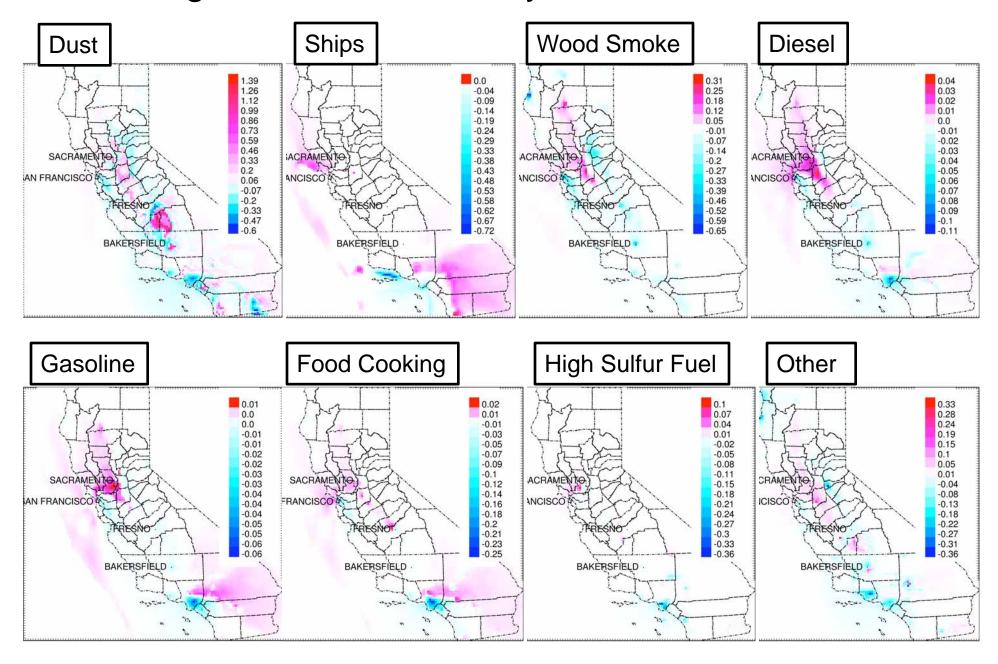
# Particle Aging Separates Particles Emitted From the Same Source at Different Times



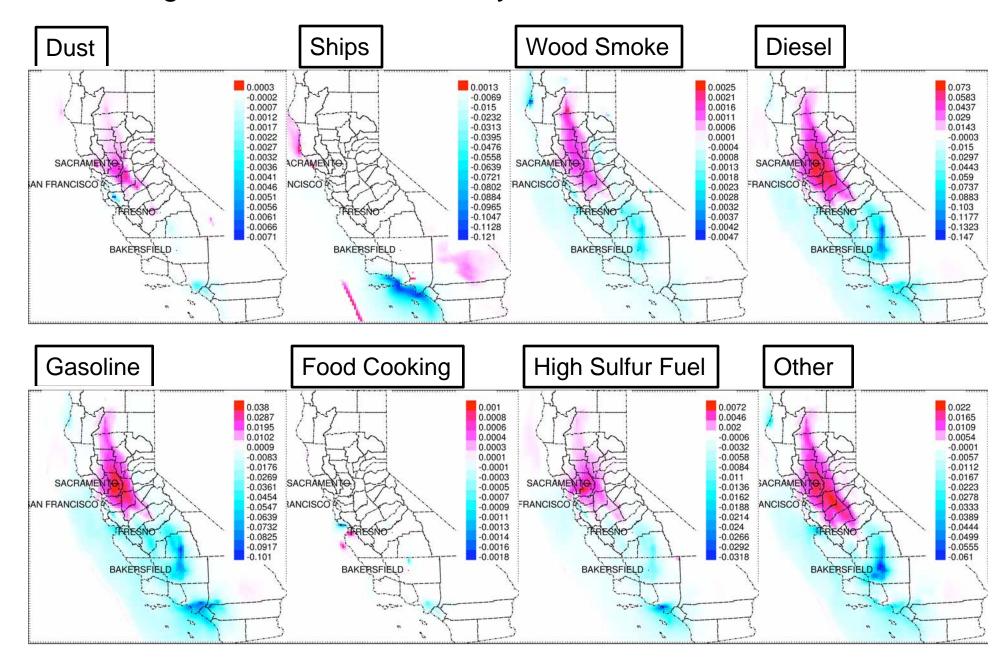
#### Source-Oriented External Mixture



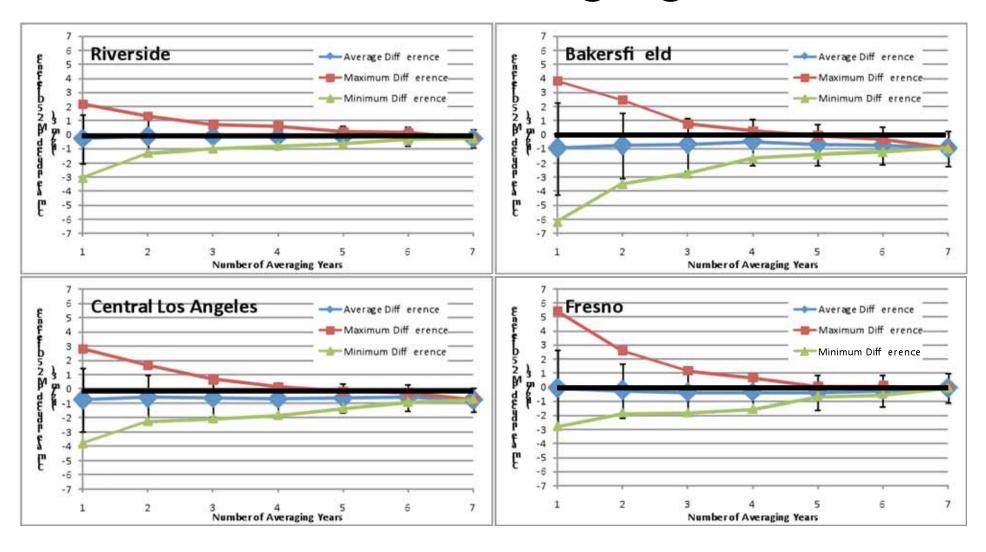
#### Changes to PM2.5 Primary Source Contributions



#### Changes to PM2.5 Secondary Nitrate Source Contributions



# Uncertainty Associated With Number of Averaging Years



# Conclusions: Climate Effects on Airborne Particle Mass in California

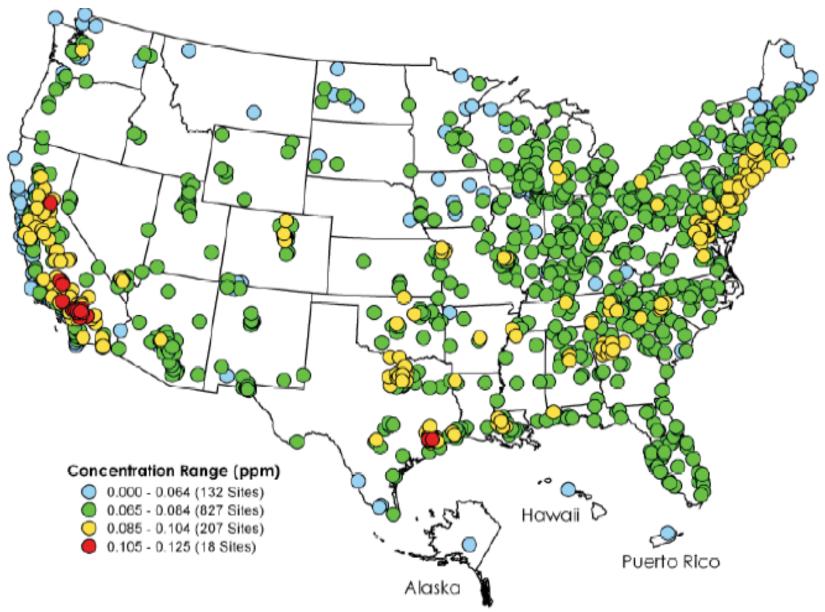
- Between 2047-53 and 2000-06
  - Increased T encourages evaporation of NH<sub>4</sub>NO<sub>3</sub>
  - Increased wind speed and mixing depths provide more dilution
  - PM2.5 increases in northern California
  - PM2.5 decreases in southern California
- Seven year analysis window is not quite long enough to reject the null hypothesis
  - H0:  $\triangle$ PM2.5=0 (no change) with P<0.05
- Need to repeat analysis using multiple, GCMs, meteorological, emissions, and air quality models: "weight of evidence" approach

## Acknowledgements

- California Air Resources Board Contract # 04-349
- United States Environmental Protection Agency Science to Achieve Results (STAR) grant # RD-83184201
- Nehzat Motallebi (CARB)
- Thanos Nenes (Georgia Tech)
- Dan Cayan, Mary Tyree, Martha Coakley, Josh Shiffrin (UCSD)

## **EXTRA SLIDES**

#### Ozone Concentrations in the US



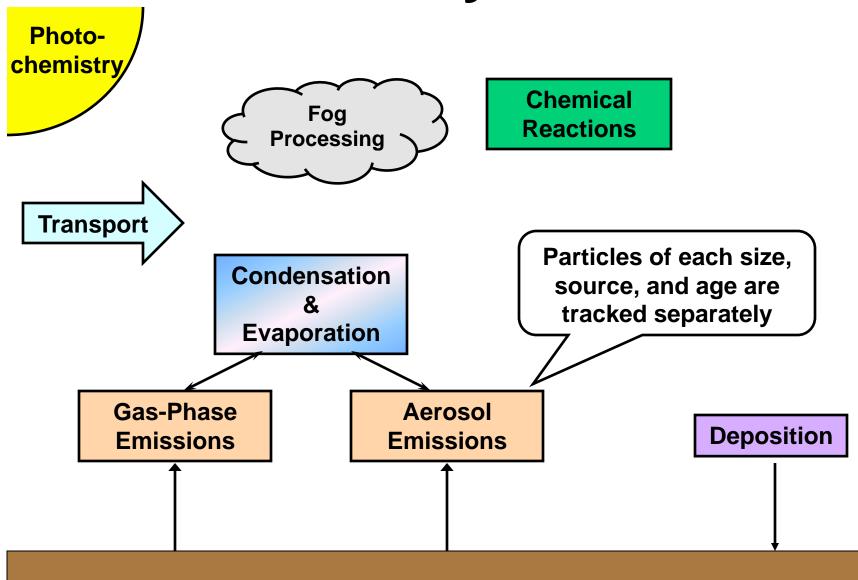
Ozone concentrations in ppm, 2006 (fourth highest daily maximum 8-hour concentrations).

Source: US EPA (http://www.epa.gov/air/airtrends/2007/report/groundlevelozone.pdf).

# How Will Climate Change Affect Air Quality?

- Air pollution events occur when meteorology traps emissions close to the surface
- Climate change will affect multiple variables simultaneously
  - Temperature, relative humidity, wind speed, mixing depth, cloud cover, precipitation, etc.

# **Air Quality Model**

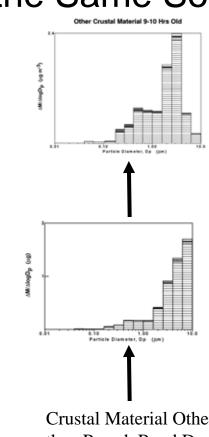


Source: Prakash Bhave, US EPA

Particle Aging Separates Particles Emitted From the Same Source at Different Times

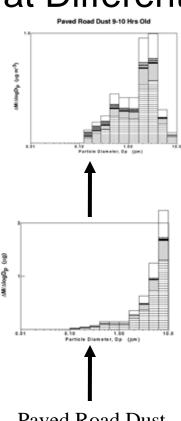
Aged **Particles** 

Fresh **Emissions** 



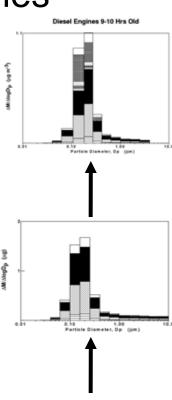
Crustal Material Other than Paved Road Dust





Paved Road Dust





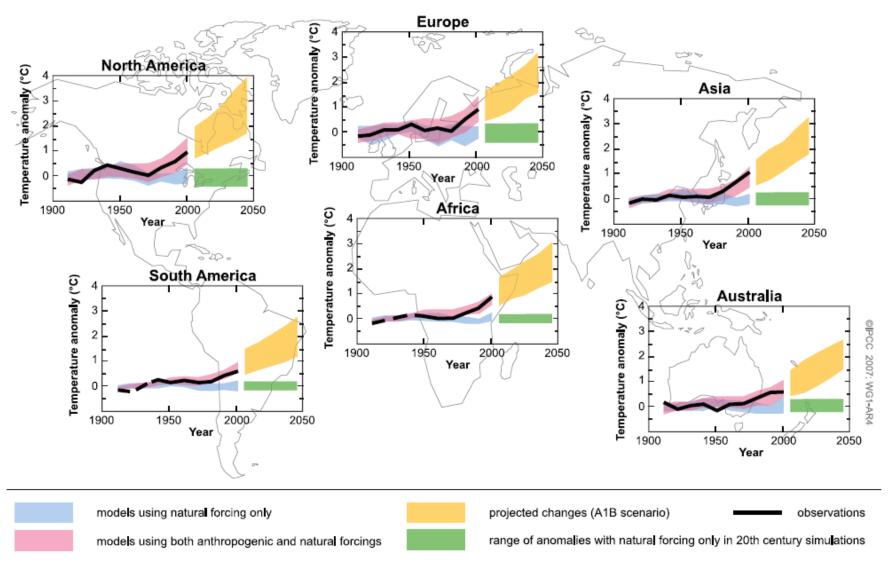
**Diesel Engines** 



## Anticipated Future Trends

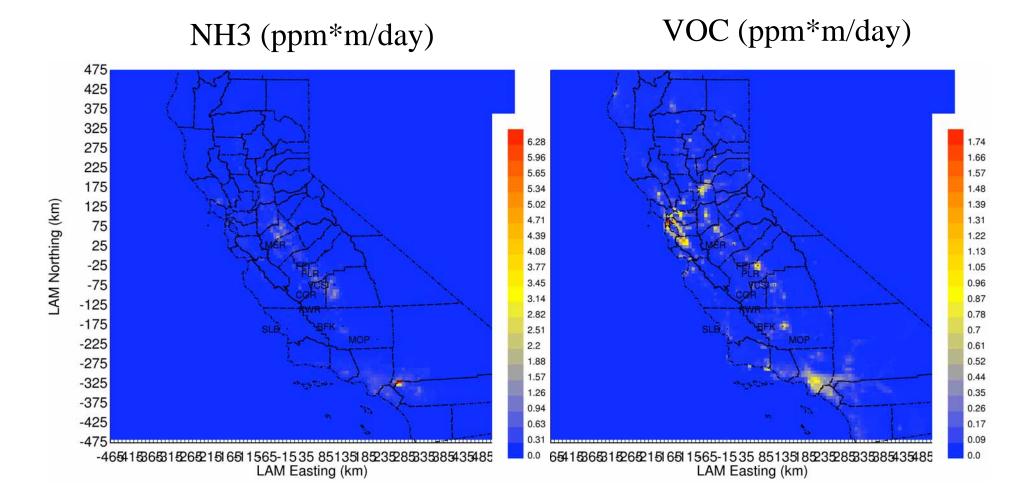
#### CONTINENTAL SURFACE TEMPERATURE ANOMALIES:

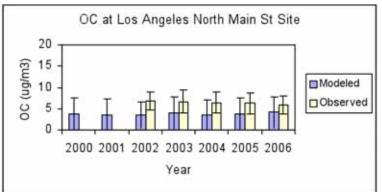
**OBSERVATIONS AND PROJECTIONS** 

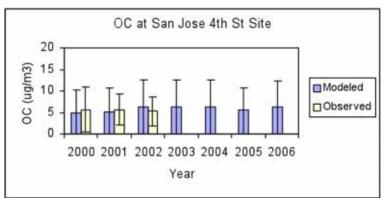


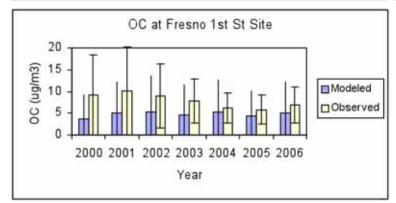
Source: IPCC Fourth Assessment

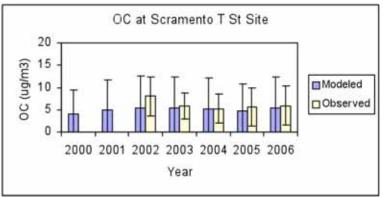
### **Basecase Emissions**

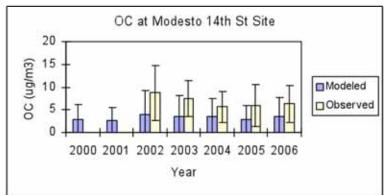


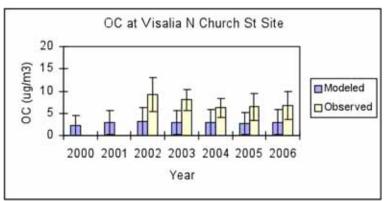


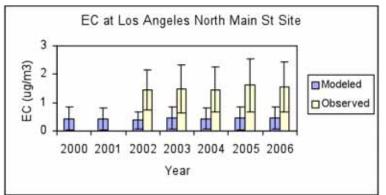


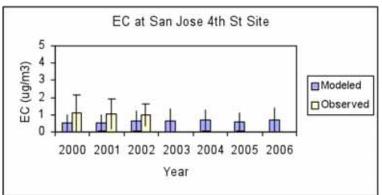


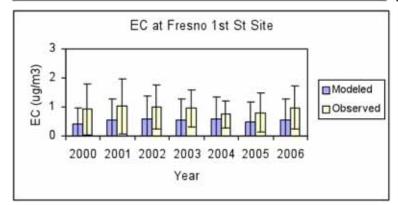


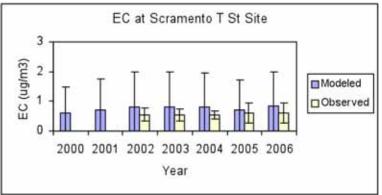


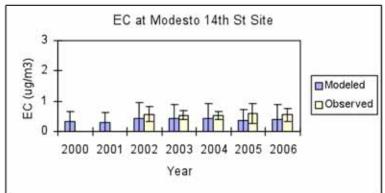


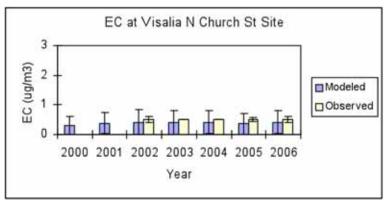


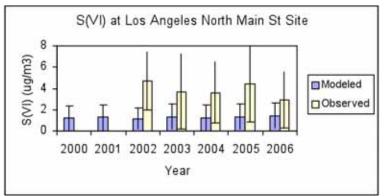


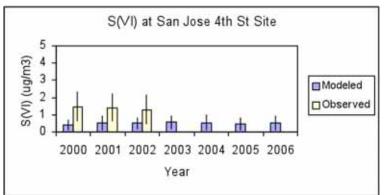


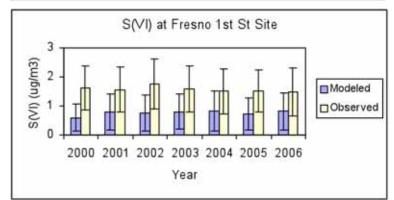


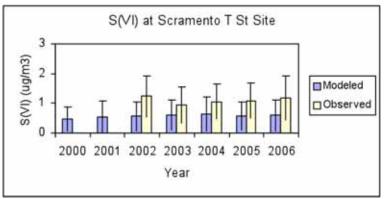


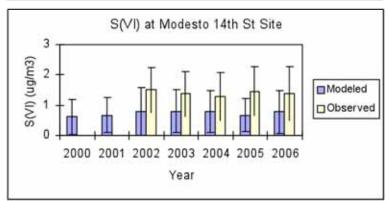


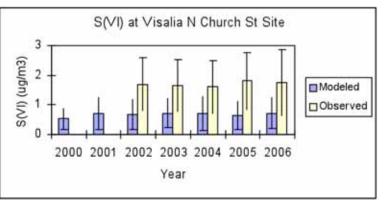


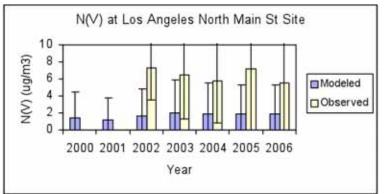


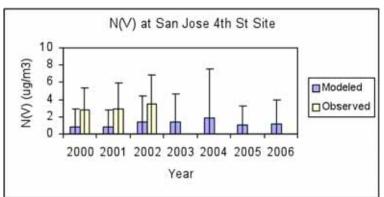


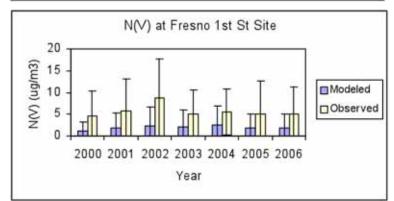


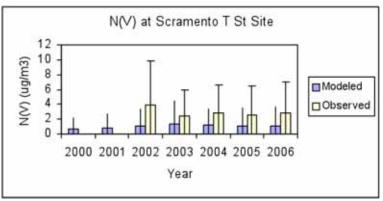


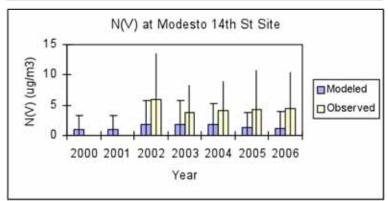


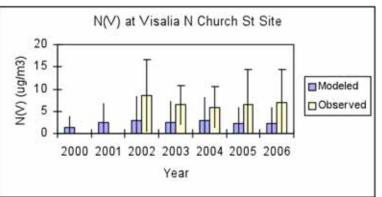


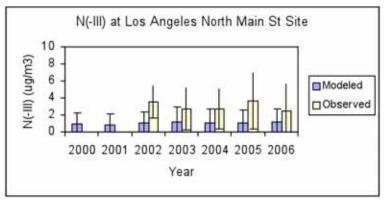


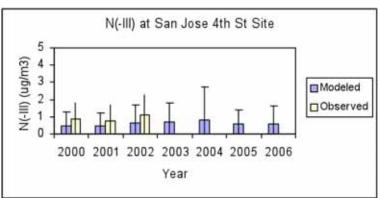


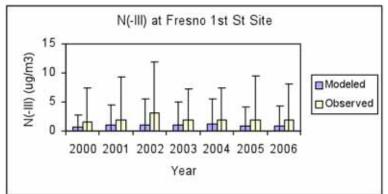


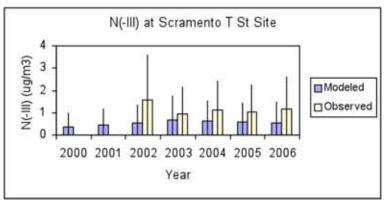


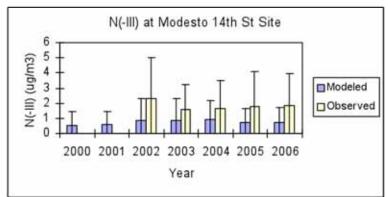


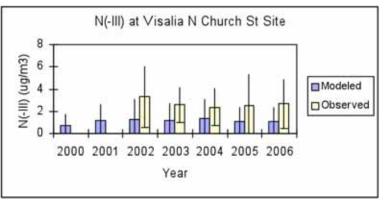








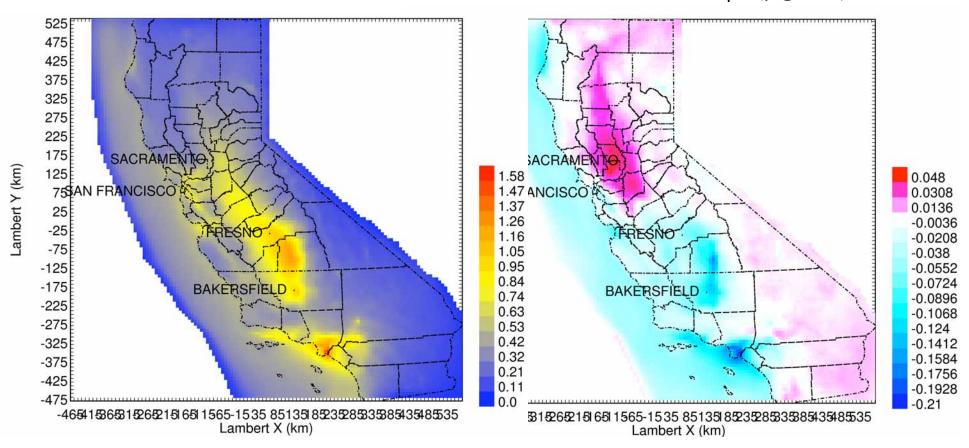




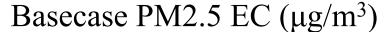
### PM2.5 NH<sub>4</sub>+ Change

Basecase PM2.5  $NH_4^+$  (µg/m<sup>3</sup>)

 $\Delta \text{ PM2.5 NH}_{4}^{+} (\mu \text{g/m}^{3})$ 



### PM2.5 EC Change



#### $\Delta$ PM2.5 EC ( $\mu$ g/m<sup>3</sup>)

